# Utilizing Six-Sigma Techniques to Improve Hospital Pre-Transplant Process

Undergraduate Research Thesis

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By

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**Abstract**

Typically, one expects to wait at a hospital or doctor's appointment. However, if patient wait times are associated with inefficient clinical processes resulting in slower clinic throughput rates, both the patient and employee grow frustrated. The pre-transplant patient process at the Comprehensive Transplant Center at The Ohio State University Medical Center has been identified as a candidate for process improvement to increase both patient and employee satisfaction. Before the Comprehensive Transplant Center can perform kidney, liver, and pancreas transplants in the abdominal transplant clinic, the patient must complete a pre-transplant process. Potential transplant patients meet individually with a team of medical professionals including a doctor, nurse, social worker, dietitian, and financial representative. This study seeks to understand the existing pre-transplant process while identifying improvements to streamline and standardize procedures. The ultimate goal is achieving improved patient throughput rates while maintaining high patient satisfaction levels. Ultimately this study sought to address a gap of about 60 minutes between the current state of appointment lengths and the redesigned future state for pre-transplant appointments. The pre-transplant process research was conducted primarily through observation. This included gathering process flow information as well as step completion times (including wait times between steps). Additionally, focus groups comprised of the aforementioned pre-transplant medical team were conducted to solicit process improvement suggestions. Utilizing the focus group suggestions and process step timing data, improvement recommendations were generated to ultimately decrease the length of time in appointments. The recommendations were developed using Lean and Six Sigma tools including process mapping, SWOT analysis (strengths, weaknesses, opportunities, and threats), spaghetti diagram, and failure modes and effects analysis (FMEA). With the captured improved process

knowledge providing the motivation for implementation, the lasting impact of this project is improved clinic patient flow, which will ultimately improve clinic efficiencies and patient satisfaction.

**Acknowledgements**

I would like to sincerely thank my research committee, Dr. Mrinalini Gadkari and Dr. Patricia West for the guidance and support throughout the process. In addition, I would like to thank the nursing staff at the Abdominal Transplant Clinic at the Ohio State University Wexner Medical Center for their support, specifically Nurse Manager Matthew Bohland and Director of Nursing Mary Lou Hauenstein. Without their support and guidance this effort would not have been possible.

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Field of Study

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## Introduction

Before any transplant can be performed at The Ohio State University Wexner Medical Center's Comprehensive Transplant Center, a patient must complete a pre-transplant process. This process first involves completing an educational program ensuring the patient understands the scope and complexity of the transplant process. After completing this educational program, the prospective transplant patient must then complete a pre-transplant appointment which involves a series of meetings with a nurse, transplant doctor, social worker, dietitian, financial representative, and in some cases a psychologist. When a patient schedules this pre-transplant appointment they are told the process will last approximately 4 hours. The overall goal of this project is to streamline and standardize the transplant clinic's pre-transplant appointment process to improve the patient throughput rate (reducing the present four hour completion time), which in turn will hopefully have a positive impact on patient satisfaction scores. Overall, the gap being addressed is approximately 60 minutes between the current state of the process and the ideal future state with the recommendations. This gap is illustrated in figure 1 in the Appendix. The benefit of shortening the pre-transplant appointments would include both increased patient and employee satisfaction as well as the ability to schedule more appointments in the clinic.

The main source of data for this project is "present condition" data which was collected by documenting the flow of transplant clinic patients. The data was collected specifically on a Tuesday in the clinic. Tuesday was chosen given it is traditionally one of the busiest days of the week at the clinic and it was likely to give the best visibility into capacity and patient flow problems within the present system. After collecting the patient flow data the data was analyzed to confirm the collected data did in fact reflect a representative sample of what the clinic administrators believe is a high demand day. With the data sets collected and confirmed as valid,

the data was investigated and areas for improved patient flow identified, areas of redundant action eliminated, and hopefully a more streamlined process identified. In addition to benchmarking an improved process flow, this project should also be capable of recognizing areas where the process could be improved given patients are not identical to each other. For instance, while every patient must go through the pre-transplant process before their transplant can be completed, some patients have to go through a pre-transplant appointment multiple times. An example of someone having to repeat the pre-transplant appointment would be an individual waiting for a liver transplant that remains on the waiting list for 3-4 years. Patients in this position might have to go through the pre-transplant process multiple times as a result of the patient's circumstances or health conditions having changed since their original pre-transplant process was completed. In the data collected, an individual who was having such a check back appointment given they had been on the waitlist for an extended period of time was marked to differentiate them from patients going through the process for the first time. Therefore, areas where the process might be tailored to accommodate unique patient circumstances, such as repeat flow through the process, were also investigated to identify possible areas for improvement.

## Literature Review and Situational Analysis

The versatility and wide applicability of Six Sigma principles makes them useful tools for contributing to continuous improvement in almost any industry, one of which is healthcare. In recent years many studies and applications of Six Sigma principles to healthcare have been accomplished resulting in significant improvements to a wide variety of hospital processes. The use of Six Sigma to improve hospital processes has significantly increased in recent years because of the changes to the American healthcare system with the passage of the Affordable Care Act of 2010. With the expansion of the healthcare system under the ACA, hospitals now require increased capacity to meet the increased demand and achieving efficiency at hospitals has become even more imperative (Johnson). The previous successful application of Six Sigma principles to hospital processes as well as previous research in this area can be applied (or tailored) to meet the goal of streamlining the transplant clinic pre-transplant process at the Comprehensive Transplant Center at The Ohio State University Wexner Medical Center.

A 2010 study of Hospital Discharge Methods walked through the application of the Six Sigma Define, Measure, Analyze, Improve, and Control (DMAIC) technique (Allen). This study provides a basic description and methodology of how Six Sigma methods can be applied to a hospital process such as the transplant clinic pre-patient process. Furthermore, a 2013 case study on improving patient discharge time provides a description of how the Six Sigma methods were applied to a hospital discharge process (El-Banna). The step-by-step methodology explanation in this study describes creating a flowchart of the process, identifying the metric, collecting the data, and performing the statistical analyses to evaluate the hospital process under study. This methodology explanation provides a solid baseline which this research effort utilized in a modified fashion to apply Six Sigma techniques to the pre-patient process at the transplant clinic.

In El-Banna's 2013 study, the discharge process at a hospital in Amman, Jordan was analyzed in order to identify ways it could be improved. The first step performed was the creation of a flowchart of the entire process. The flowchart identified all the steps a patient went through from the specialist signing the discharge order all the way to the accounting department finally issuing the hospital bill. Once this flowchart was created, a metric was identified to be measured and optimized which was the completion time of each specific process step. Observations of the step completion times were in turn collected over a series of five weeks and once the data was collected a statistical analysis was performed. The statistical analysis included looking for outliers, defining the distribution, looking at control charts to determine if the process was under control (as defined by Six Sigma metrics), and finally determining the sigma level for the process. Next, the results were compiled utilizing tools such as a fishbone diagram to identify the causes for delays. Finally, a simulation model was created and based upon the results of the simulation model, solutions were proposed, tested in simulation, and finally put into place in the real hospital process. Once this was completed, observations of the changed process were collected in the actual hospital setting and further statistical analyses were carried out. Once the model was identified and confirmed in practice as showing improvement, the improvement process was ended and the process now is monitored periodically in order to ensure that the improvement was maintained. (El-Banna).

## Methodology

The research methodology that was used primarily in this effort involved the application of Six Sigma Principles. These principles included the application of the DMAIC process, which goes through the steps of Define, Measure, Analyze, Improve, and Control.

The primary set of data collected and used to direct this effort consisted of present condition observations of the current process. Based on these it was determined if the actual process is in reality the process the clinical staff thought they were executing. The collected observations also allow any bottlenecks in the process to be identified. To capture the collected observations, a series of patients were actually timed through the process. No patient specific data was collected in the process since patients were simply numbered and all collected data did not involve any confidential patient identifying information, including the patient name. In addition, when these observations were made, the only information collected was the order in which the patient went through the series of appointments and the times they spent in each meeting with the respective medical professional (such as the nurse or transplant doctor). All of these observations were collected without having to be in patient's room, his or her physical proximity, or being exposed to any confidential patient information.

Based on these observations the results were compiled in order to have a clear understanding of the process currently being followed with the actual times patients spent in each appointment. With the information about how long each appointment was actually taking, times patients were waiting between meetings, as well as the identification of bottlenecks, recommendations for improvement were able to be made to the hospital.

In addition to the collection of actual clinic performance data, a focus group was held with the nurses and other medical professionals who work in the transplant center. It is important

to involve these individuals who actually see and work with the process on a daily basis so that lasting improvements can be made. The purpose of this focus group was to map out the process to ensure everyone is on the same page as to the current state. In addition, the focus group performed a SWOT analysis to take into account the input of the individuals that are involved with this process every day. The focus group was a discussion-based conversation in which participants were able to talk as a group through the process the patients go through in the pre-patient process. The conversations began simply by asking them to "Tell me about your day" and then have them talk through the process. As the discussion became centered on different parts of the process, the medical professional that was most directly involved in that part of the process took the lead in talking about that part of the process. The key in this discussion was to ask the "why" questions to understand why each step is taken and begin to identify areas where there is possible waste and how processes might be changed. It was important to talk through the process in order to make sure that everyone fully understood the entire process and that each part of the process was thought about in terms of ways improvements could be made. By identifying all of the activities and where time was being spent, improvement recommendations were able to become more focused. Furthermore, talking through the process with a team, rather than just a single person, allowed variation to be identified in the process. By involving the medical professionals in this process it will hopefully also contribute to lasting continuous improvement by increasing their engagement with the research.

The results from these first steps of the research were crucial in guiding the completion of the improvement phase of this research. Based on what was identified as being the main area for improvement, appropriate measures were designed. With the recommendations developed, an appropriate plan for implementation was designed.

## Results

With the completion of the patient observations as well as conversations with members of the medical professional staff, the process was more clearly understood and the gap the project was addressing was able to be clearly defined. The gap that is being addressed can be seen in figure 1. Across all of the observations (which can be found in Appendix A), it was found that on average the appointments take 208 minutes (about 3.5 hours). The goal that was established with the clinic staff given the approximations for each of the meetings was a total of 145 minutes. Thus, the gap that is being addressed is just over 60 minutes.

The comprehensive process map of the current state of the process can be seen in figure 2. The individualized patient observation data used to support the generation of the process map can be found in Appendix A. In addition to using the patient observation data to generate the process map, the observation data was also used to generate a spaghetti diagram to depict the motion throughout the clinic. The spaghetti diagram tracks all of the physical movement during the course of an appointment. The spaghetti diagram found in figure 3 tracks all of the physical movement involved in patient one and two's appointment. Each different colored line on the spaghetti diagram represents a different medical professional and the movements they made in order to complete their tasks during the appointment. Since all of the patients were relatively similar, for simplicity only two patients were depicted in the spaghetti diagram to represent the typical movement through the clinic during a typical appointment.

The breakdown of how the time was spent during patient one and two's appointment can be seen in the pie charts found in figure 4. When the patient is simply sitting in the exam or consult room waiting to meet with the next medical professional, this time is non-value added for the patient. The pie charts visually illustrate that a large percentage of the appointment time is

actually non-value added waiting time for the patient. For patient one wait time is about 46% of the appointment (101 minutes out of the total 218 minute appointment). For patient two, the wait time comprises about 34% of the total appointment length (86 minutes out of the total 253 minute appointment). While this data represents only two of the patients that went through the process, the other patients' data can be found in Appendix A and is seen to also reflect high wait times during the appointment.

On December 14, 2016 a focus group was held with a representative group of medical professionals that work directly with the pre-transplant patients, and specifically the professionals that were involved with the pre-transplant appointments that were being studied in this project. At this focus group, the process was talked through in order to ensure that everyone was on the same page as to the process the patient goes through at one of these appointments. With the completion of this step and an agreement as to the process, the group moved into doing a SWOT analysis of the current state of the pre-transplant appointment process. The group brainstormed the strengths, weaknesses, opportunities, and threats of the current process. The results of this discussion can be seen in figure 5.

With the process map and SWOT analyses completed, a Failure Modes and Effects Analysis (FMEA) was created for use by the hospital staff. The FMEA can be seen in figure 6. To conduct the FMEA, each process step (based on the process map in figure 1) was methodically analyzed in terms of the function of that step, potential failure modes, potential causes of failure, and current controls in place for preventing this failure. This information was put together so the clinic staff can review and think about each of these process step failures in terms of the likelihood of occurrence, severity, and probably of detection. Each of the process steps can be given a rating for each of the three factors on a scale of 1 to 5. The rubric scale for

what each of the different assigned numbers mean can be seen in figure 7. Once all of the ratings are completed for each step, those three numbers (occurrence, severity, and detection) can be multiplied together in order to calculate an RPN or Risk Priority Number. This makes it evident which steps of the process should be prioritized for improvement. This tool was provided for the hospital clinic staff to utilize to formulate and prioritize possible improvements.

On March 9, 2017 a brainstorming event was held with the clinic transplant team to bring together all of the tools and results to finalize tangible ways to improve the clinic task flow for the pre-transplant process. While there were a wide variety of ideas as to how to improve clinic flow, the ultimate decision leaving this meeting involved making a change to the process to pre-schedule the individual meetings during the pre-transplant appointments. This suggestion was rooted in a desire to eliminate the long wait times associated with the nurse having to coordinate the flow of meetings as well as the time spent waiting while the nurse could locate clinic staff needed for the next meeting. In addition, as a team, goals for the duration of each of the appointments were discussed and standards agreed upon for the lengths of these meetings can be seen in figure 8. With these decisions reached and agreed upon by the team, an implementation plan was designed. The next steps for the process involve coming up with the specific scheduling methodology to be used, a task that will be completed a team of process engineers and was beyond the scope of this effort. From there, the new scheduling system will be piloted at the clinic on a few set days in order to work out any issues that might arise. Once the pilot is completed, the scheduling will ideally be implemented across all pre-transplant appointments at the clinic.

With the completion of the pilot, the time it takes patients to complete the pre-transplant appointment will be compared to the baseline data collected to ensure that this is indeed

improving patient throughput times. In addition, the clinic staff will be consulted to hear their thoughts on the process changes. This staff feedback is important because they are the ones most directly affected by the process on an everyday basis. Since they interact with the process they likely will have insights as to any bottlenecks or issues that have arisen that need to be addressed. This is a crucial step in the DMAIC process since they are the ones who know the process best. The implementation and next steps in achieving improvement are further discussed in the "Discussion and Conclusion" section.

**Figure 1. Gap Between Current State and Goal State**

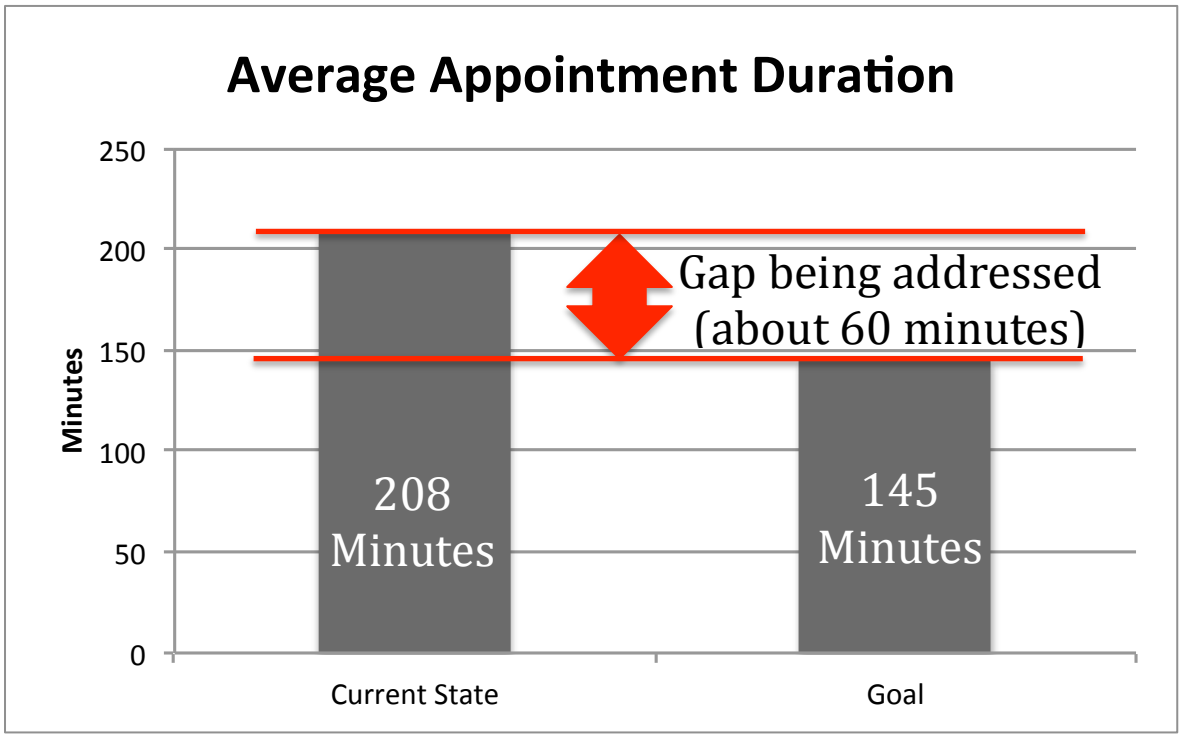


**Figure 2. Process Map**

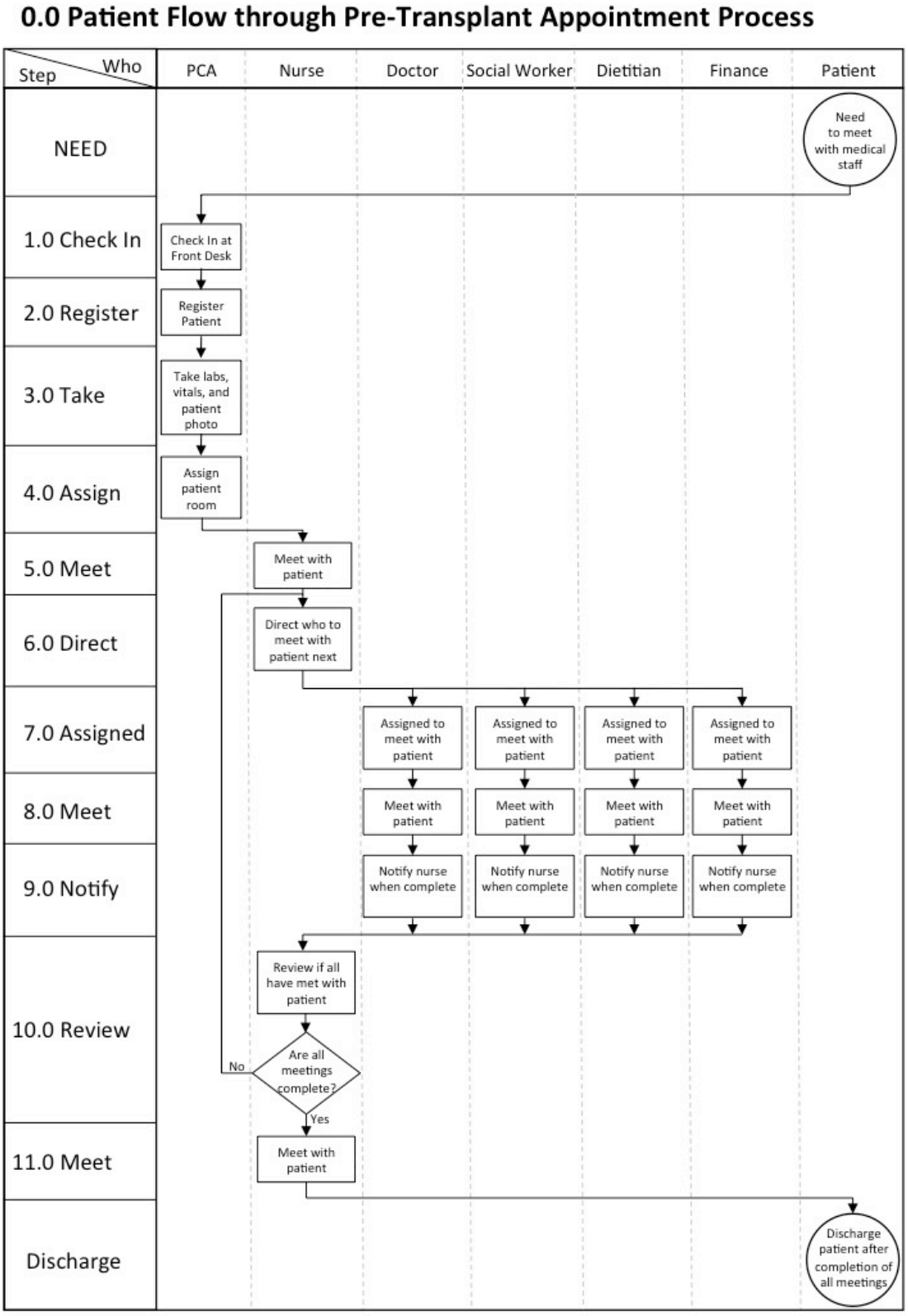


**Figure 3. Spaghetti Diagram**

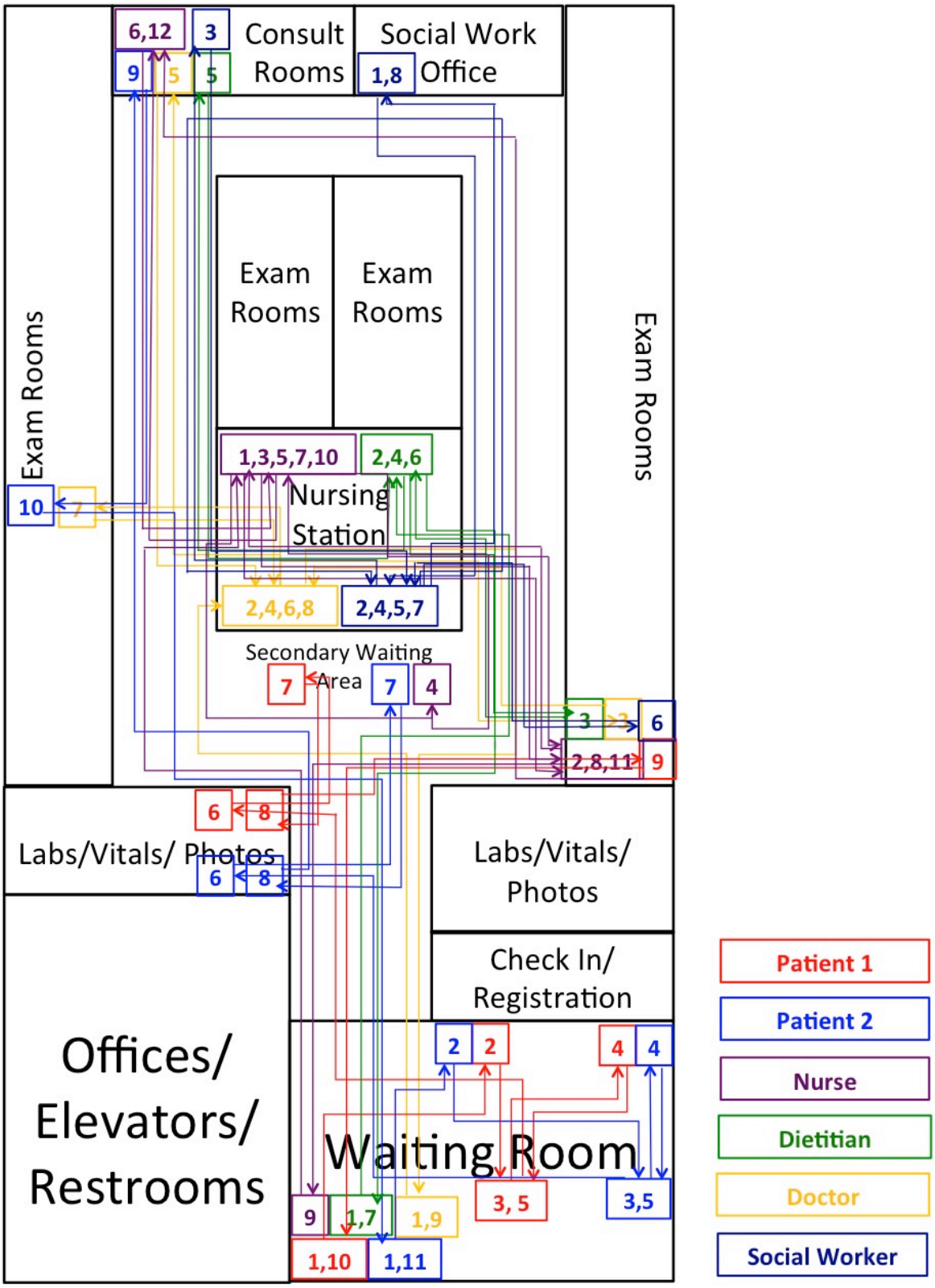
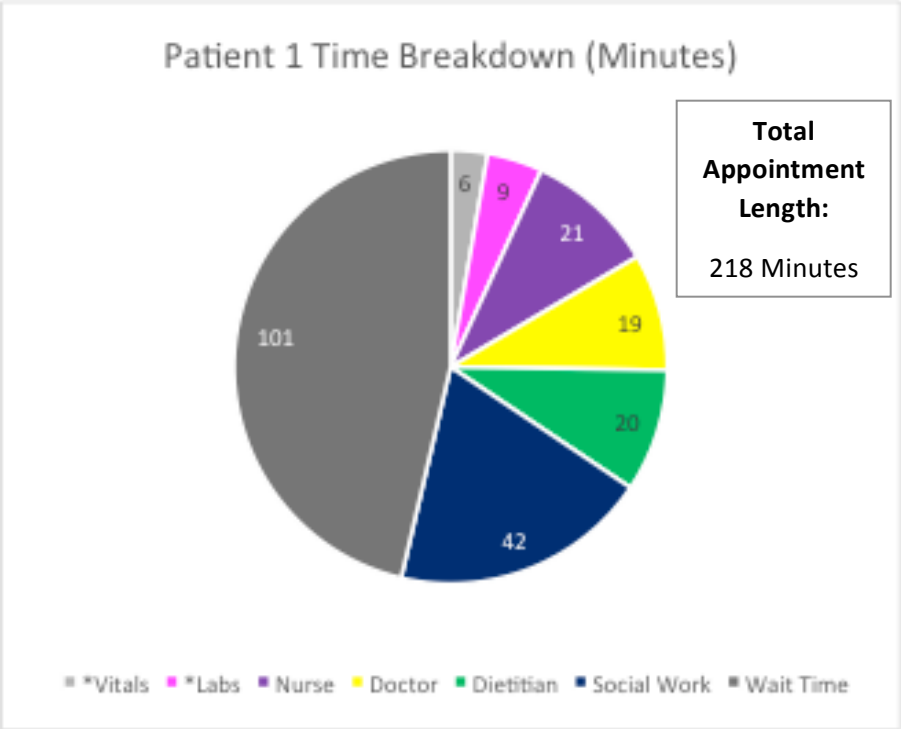


**Figure 4. Current State Pre-Transplant Appointment Breakdowns**



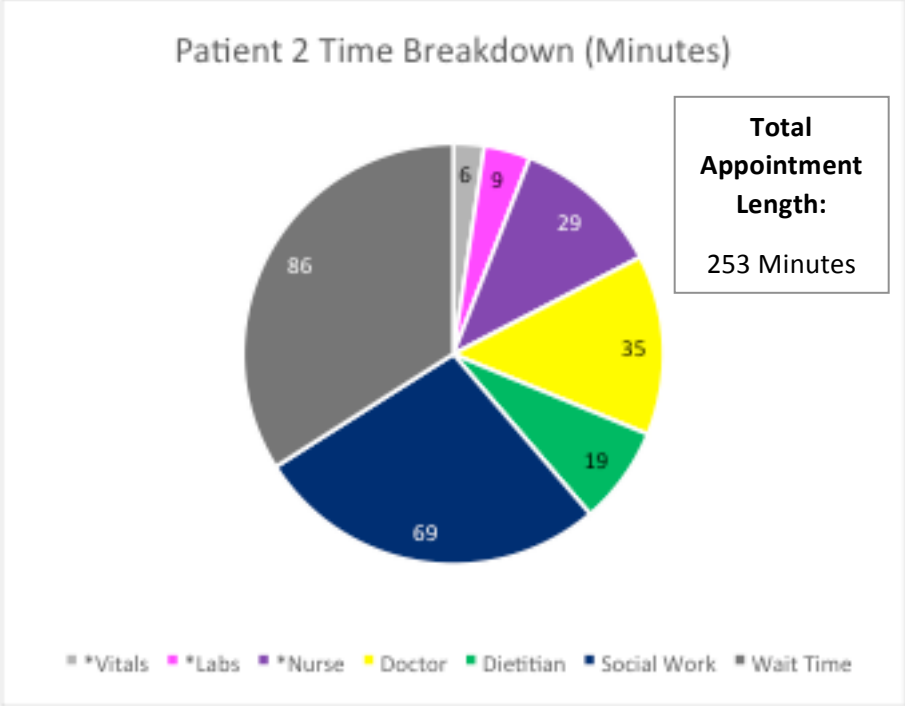
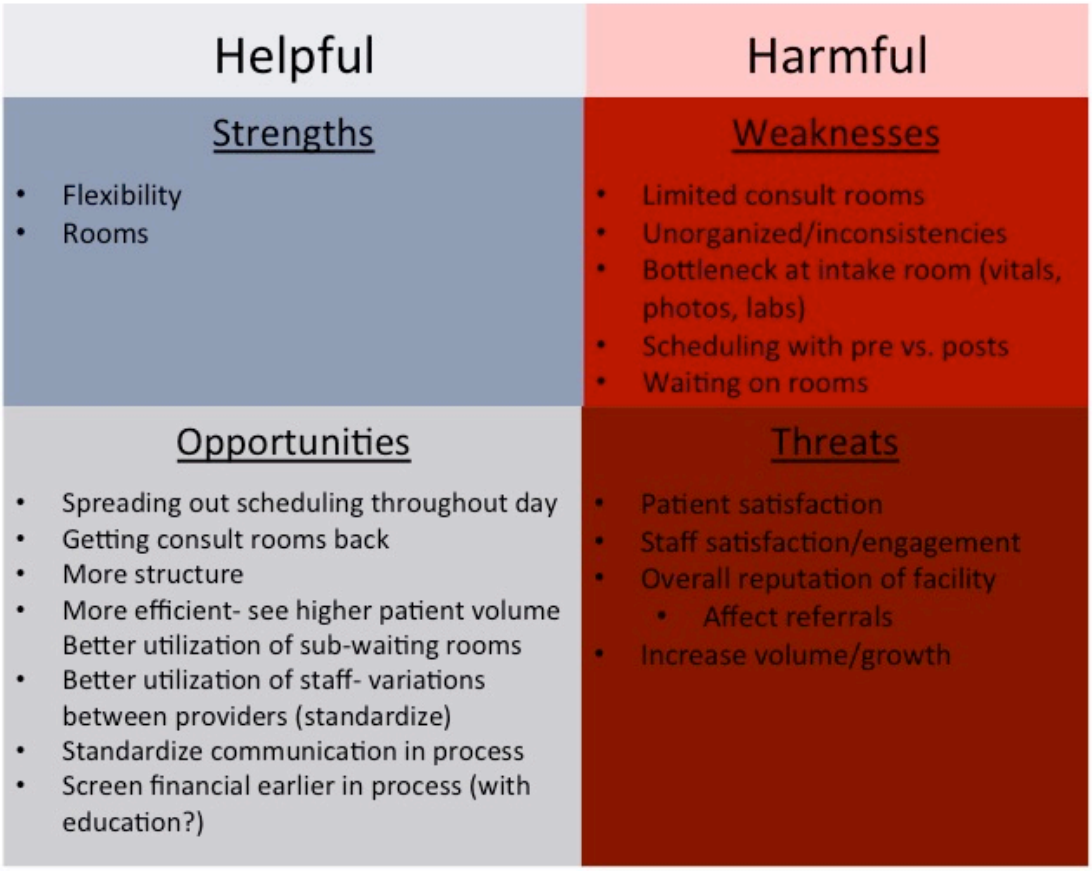



**Figure 5. SWOT Analysis of Current State of Pre-Transplant Process**



# Figure 6. Failure Modes and Effects Analysis

| Step Number | Process Step | Review Process Step Function | Potential Failure Modes | Potential Causes of Failures | Potential Effects of Failures | Current Controls | Existing Conditions | | | | Recommended Actions | Resulting Conditions | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | OCC | SEV | DET | RPN | | OCC | SEV | DET | RPN | |
| 1 | Patient Signs in on clipboard at front desk | The clinic knows the patient has arrived and can begin the registration process | Patient doesn't sign in, simply takes a seat in waiting area | Patient is unaware that they need to sign in/accidentally forgets | Delays the rest of the process/start of registration for the patient | Signs in the lobby tell the patient to sign in; PCA at front desk pays attention to make sure that all patients entering sign in | | | | | | | | | | |
| 2 | Patient is registered | The patient is called to the registration desk in order to verify insurance, address, phone number, personal information | Patient is not called to be registered; Patient information is not properly updated | Miscommunication/no communication between check in and registration staff | Delays the rest of the process; the patients personal information is not updated or must be updated in a hurry | Registration and check in people sit right next to each other in order to have constant communication; patient cannot be called back until their paperwork is passed to PCA taking them back | | | | | | | | | | |
| 3 | Patient gets labs, vitals, and photos | Patient is called back to have the necessary information and measurements be taken by PCAs | PCA doing these tasks does not realize that the patient is done registering to take them back; not all of the necessary information is taken | PCA is unaware that patient is ready to have their labs/vitals; human error in not getting all of the necessary information | Later in the appointment will not have all of the necessary medical information; delay start of rest of appointment | Patient is taken directly to the lab as first step | | | | | | | | | | |
| 4 | Patient put in a room | Once a patient's labs, vitals, and other information is all taken the patient is placed in an exam or consult room based on availability | Patient is not placed in a room | No rooms are available | Next medical professional cannot meet with a patient because they aren't in a room yet | | | | | | | | | | | |
| 5 | Nurse coordinator goes in to meet with patient for first time | Once the patient is roomed the coordinator goes into the room to meet with them | Nurse doesn't go in immediately and patient ends up waiting | Nurse is busy; nurse does not realize that they have been roomed/are ready | The patient ends up waiting in the room which delays the rest of the appointment | Screen at the nurse station that they update with patient room numbers | | | | | | | | | | |
| 6 | Nurse Coordinator Assigns Professional Staff to Meet with Patient | Nurse coordinator reviews professional staff availability and determines who sees the patient first | Staff member selected by nurse coordinator is not able to see patient in a timely manner | Nurse coordinator does not have accurate staff availability information, No staff members are available | Patient wait time increases until assigned staff member is available | Nurse coordinator tries to track/contact staff to determine who should meet with patient next | | | | | | | | | | |
| 7a | Doctor is Assigned to Meet with Patient | The nurse coordinator assigns who goes in next, such as the doctor | Doctor is not available to meet with the patient | Doctor is working with other patients | Delays rest of appointments | | | | | | | | | | | |
| 8a | Doctor Meets With Patient | Doctor covers necessary medical information with patient | Doctor is unable to cover information with patient | Lab results are not complete, patient information is not correct, interrupted by outside contact | Delays completion of appointment, may require the doctor to come back later to finish appointment | | | | | | | | | | | |
| 9a | The doctor alerts the nurse coordinator that they are done | Nurse coordinator knows they can direct next medical professional to go in to meet with patient | The medical professional does not tell nurse coordinator that they are done | Nurse coordinator is off doing something else (medical professional can't find); medical professional forgets to tell nurse coordinator they are done | Delays rest of meetings/patient ends up waiting | | | | | | | | | | | |
| 7b | Dietitian is Assigned to Meet With Patient | The nurse coordinator assigns who goes in next, such as the doctor | Doctor is not available to meet with the patient | Doctor is working with other patients | Delays rest of appointments | | | | | | | | | | | |
| 8b | Dietitian Meets with Patient | Dietitian covers necessary nutritional information with patient | Dietitian is unable to cover information with patient | Patient information is not correct, Appointment is interrupted by outside contact | Delays completion of appointment, may require the dietitian to come back later to finish appointment | | | | | | | | | | | |

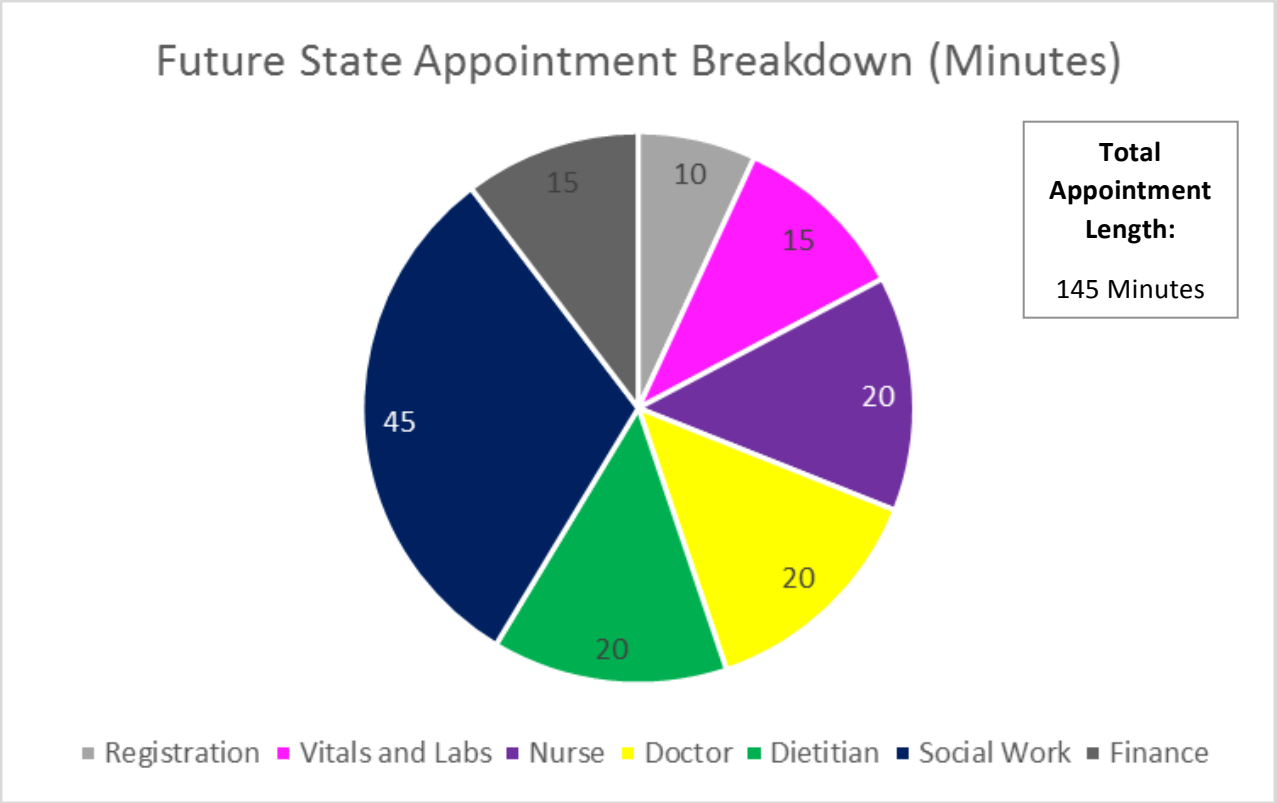
## Figure 6. (Continued) Failure Modes and Effects Analysis

| Step Number | Process Step | Review Process Step Function | Potential Failure Modes | Potential Causes of Failures | Potential Effects of Failures | Current Controls | Existing Conditions | | | | Recommended Actions | Resulting Conditions | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | OCC | SEV | DET | RPN | | OCC | SEV | DET | RPN | |
| 9b | The dietitian alerts the nurse coordinator that they are done | Nurse coordinator knows they can direct next medical professional to go in to meet with patient | The dietitian does not tell nurse coordinator that they are done | Nurse coordinator is off doing something else (medical professional can't find); medical professional forgets to tell nurse coordinator they are done | Delays rest of meetings/patient ends up waiting | | | | | | | | | | | |
| 7c | Finance worker is assigned to Meet with Patient | The nurse coordinator assigns who goes in next, such as finance worker | Finance worker is not available to meet with the patient | Finance representative is not available to meet with patient | Delays rest of appointment | | | | | | | | | | | |
| 8c | Finance Meets With Patient | Finance covers necessary financial information with patient | Finance is unable to cover information with patient | Patient information is not correct, Appointment is interrupted by outside contact | Delays completion of appointment, may require the dietitian to come back later to finish appointment | | | | | | | | | | | |
| 9c | Finance alerts the nurse coordinator that they are done | Nurse coordinator knows they can direct next medical professional to go in to meet with patient | The medical professional does not tell nurse coordinator that they are done | Nurse coordinator is off doing something else (medical professional can't find); medical professional forgets to tell nurse coordinator they are done | Delays rest of meetings/patient ends up waiting | | | | | | | | | | | |
| 7d | Social Worker is Assigned to Meet with Patient | The nurse coordinator assigns who goes in next, such as Social Worker | Social Worker is not available to meet with the patient | Social Worker is not available to meet with patient | Delays rest of appointment | | | | | | | | | | | |
| 8d | Social Worker Meets with Patient | Social worker covers necessary support network/psychological information with patient | Social worker is unable to cover information with patient | Patient information is not correct, appointment is interrupted by outside contact | Delays completion of appointment, may require the Social Worker to come back later to finish appointment | | | | | | | | | | | |
| 9d | The Social Worker alerts the nurse coordinator that they are done | Nurse coordinator knows they can direct next medical professional to go in to meet with patient | The medical professional does not tell nurse coordinator that they are done | Nurse coordinator is off doing something else (medical professional can't find); medical professional forgets to tell nurse coordinator they are done | Delays rest of meetings/patient ends up waiting | | | | | | | | | | | |
| 10 | Nurse Coordinator Reviews Staff Member Meetings Completed | The nurse coordinator assigns who goes in next, such as the dietitian | Nurse Manager is not available to meet with patient; doesn't track that all medical professionals have finished | Nurse Manager was busy doing other things and didn't realize all meetings were completed; Medical professionals didn't alert nurse that they were done | Delays rest of appointment | Nurse coordinator has a checklist on top of patient paperwork where they check off when each medical professional meets with patient | | | | | | | | | | |
| 11 | Nurse Coordinator Meets With the Patient for Final Time | The nurse provides a final plan of action/answers any final questions that the patient may have | Nurse does not go to see patient | Nurse does not know patient is ready to be seen; Nurse is busy doing something else and does not know patient is ready to be seen | Even though the main portion of the appointment is done, the patient ends up waiting longer | | | | | | | | | | | |
| 12 | Appointment Check Out Process | Patient has completed pre-transplant process | Patient does not complete all necessary appointments | Patient does not wait to see all professional staff, professional staff not available | Patient has to come back for another appointment | | | | | | | | | | | |

**Figure 7. Failure Modes and Effects Analysis Rating Scale**

| | | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| Severity | How likely this is to result in the patient leaving before the completion of all appointments or needing to reschedule appointment | Never | Rarely | Maybe | Probably | Likely |
| Occurrence | How likely is the failure mode to occur | Never | Rarely | Maybe | Probably | Likely |
| Detection | How likely is it that the failure mode would not be detected | Never | Rarely | Maybe | Probably | Likely |

**Figure 8. Future State Pre-Transplant Appointment Breakdown**



## Discussion and Conclusion

With the clear understanding of the process of the pre-transplant appointment established, recommendations were generated to make these appointments more efficient for the clinic. While these recommendations have not yet been implemented, that is the next step for the clinic. After analyzing the observations of process task times in the clinic, it became very clear that a huge part of the pre-transplant appointment is simply wait time for the patient. Since this time is not value added, recommendations were centered on ways to reduce this wait time. As can be seen in the current state process map, once the nurse completes the initial assessment, there is not a clear order of operations for the rest of the medical professionals to meet with the patient. Since this lack of a clear order is a cause of significant patient wait time, ways to reduce the variation were identified. Utilizing the insights from a team of the medical professionals that work in the clinic, the goal duration for each of the meetings was established. These goal times were compared to the actual timing data observed. It was found that the actual appointment times from the observations were very much in line with the established goal times for each of the meetings. The goal lengths for each of the appointments can be seen in figure 8. The conclusion can therefore be reached that the process variability did not rest as much in the actual appointment times as it did in the variability that was present due to what happened between the meetings.

With the lengths of time for each of the meetings during the appointment established, the order of operations was discussed with the team. It was established which steps in the process need to be completed before other steps. With the establishment of the lengths of each of the appointments, along with the optimized (rather than random) order of appointments, schedules can be created. The goal is that each of the meetings during the course of the longer pre-transplant appointment will be pre-scheduled in order to create efficiencies for both the clinic

and the employee. For example, if the Social Worker knows that they are to meet with Patient A at 10:30AM and then Patient B at 11:30AM they will be able to better plan and not spend time traveling through the clinic looking for the nurse coordinator to find out when they need to meet with each patient. Furthermore, the nurse manager will not have to spend as much time each day verbally directing people when to go meet with each patient. While this recommendation seemed to have a large amount of support and buy in from across the medical team, there will still need to be a pilot process. At this point, process engineers are working on creating a couple different mock schedules for what these appointment schedules will actually look like. These preliminary schedules will be sent to the team to hear their thoughts on which appointment scheduling methodology will be most effective.

One major consideration to include in determining the scheduling methodology would be that while many appointments are similar in length, certain patients might have special circumstances that would result in longer meetings with each medical professional. In order to not overcomplicate the scheduling system, a second type of schedule will be created which will block out twice as much time for this patient's meetings with each medical professional. While each patient's circumstance is different and some of these special appointments may not require twice as much time, the decision to only have the two appointment types was a result of a desire to keep the system as simple as possible.

Once a schedule approach has been developed, the pre-scheduling of the various professional staff meetings within appointments will be piloted with a limited number of patients on a set day. On this day, the process engineers will be on site observing and helping to ensure a smooth implementation. Once the pilot has been completed, appropriate changes and adjustments will be made to ensure that the implementation of pre-scheduling will benefit the

clinic and the patients. The appointment lengths for the appointments once the pre-scheduling is implemented will be compared to the baseline data (found in Appendix A) to ensure that this does in fact result in improvements in throughput time for the clinic.

In terms of future research, many of the lessons learned and methodologies utilized in this effort can likely be applied to the post-transplant appointment process at the clinic. Once the recommendations have been implemented and the improvements in terms of appointment length have been quantified, it can be determined whether it would be beneficial to carry out a similar process looking at the post-transplant process. In addition, the living donors that donate their organs to the clinic have a very different appointment process that might have room for improvements as well. While those are two processes that could be analyzed at this clinic, there are many other clinics that likely have room for improvement in terms of the process flow.

## References

Allen, T. T., Shih-Hsien Tseng, Swanson, K., & McClay, M. A. (2010). Improving the hospital discharge process with six sigma methods. *Quality Engineering, 22*(1), 13-20.

El-Banna, M. (2013). *Patient discharge time improvement by using the six sigma approach: A case study* Taylor & Francis Ltd.

Johnson, M., & Capasso, V. (2012). Improving patient flow through a better discharge process. *Journal of Healthcare Management, 57*(2), 89-93.

## Appendix A: Observation Data by Patient

**Patient 1 Timeline**

Appointment Date: November 22, 2016

Appointment Time: 10 AM

Patient Arrival: 9:30 AM

(When they arrived, no rooms were available so they waited in main waiting room)

10:15AM: Still waiting on a room to be available

10:30AM: Vitals have been taken, they are now waiting for labs in the smaller waiting room

10:33AM: Exam room assigned, but the patient was in the lab (As soon as room was assigned, nurse went to check on almost immediately, but patient was in waiting room)

10:37AM: Nurse went to do her initial evaluation with patient

10:58AM: Nurse completed initial evaluation

10:58 AM: Nurse sent dietitian in to meet with patient

11:10AM: Doctor said he was ready to see patient, but nurse wasn't around to touch base (was meeting with patient 2) so he kept working on computer

11:18 AM: Dietitian done with patient

11:28AM: Nurse returned from meeting with Patient 2, and began discussing patient 1 with doctor

11:33AM: Doctor and nurse done discussing and doctor entered patient's room

11:52AM: Doctor done meeting with patient, returned to nurse station where doctor and nurse began discussing patient 2

12:00PM: Nurse called Social Worker to go meet with patient

12:26PM: Social Worker entered patient's room

1:08PM: Social worker done meeting with patient- Social worker came back to nursing station looking for nurse, but when nurse wasn't there the Social Worker went back to the Social Work Office

VITALS:

NURSE: 21 minutes

DIETITIAN: 20 minutes

DOCTOR: 19 minutes

SOCIAL WORK: 42 minutes

**Patient 2 Timeline**

Appointment Date: November 22, 2016

Appointment Time: 10AM

Patient Arrival: 10:04AM

11:27AM: Nurse done with initial evaluation and nurse sent dietitian in

11:28AM: Dietitian entered patient's room

11:49AM: Dietitian finished meeting with patient

11:52AM: Doctor and nurse began discussing patient 2 based on nurse's already completed assessment

12:03PM: Nurse went to go check on patient while Doctor continued to look over charts

12:04PM: Nurse returned from checking on patient

12:10PM: Doctor went to meet with patient

12:45PM: Doctor done meeting with patient

12:47PM: Nurse called for Social Work to let them know the patient was ready for the Social Worker

12:50PM: Nurse went to check on patient

12:57PM: Nurse back from talking to patient

1:00PM: Social Worker came to nurse station to find out what room the patient was but when the nurse wasn't there nor was the room number displayed on the screen next to the patient's name, the Social Worker went to look for someone to help her

1:01PM: Social Worker and PCA came back to patient's room and made sure it was correct room- Social Worker entered patient room

2:10PM: Social Worker done meeting with patient

2:15PM: Nurse returned to patient room

2:17PM: Nurse and patient left room

NURSE: Unknown

DIETITIAN: 19 minutes

DOCTOR: 35 minutes

SOCIAL WORK: 69 minutes

**Patient 3 Timeline**

Appointment Date: November 29, 2016

Appointment Time: 10 AM

Patient Arrival: 9:30 AM

9:40AM: Patient was taken to get vitals

9:42AM: Nurse went to look for a room that could be assigned to him, but there were no rooms available

9:52AM: Screen switched to "Vitals Rm" for patient

9:53AM: Screen switched to "Clinic 3" for patient

9:53 AM: Nurse went to do initial assessment with patient

10:16 AM: Nurse done with initial assessment

11:05 AM: Dietitian done from meeting with patient and nurse and dietitian began discussing

11:10 AM: Dietitian and nurse done discussing

11:33 AM: Nurse and Doctor began discussing patient

11:40 AM: Doctor went to see patient

11:44 AM: Social Worker told nurse that the doctor was seeing patient in consult room- nurse went to go move patient

11:45AM: Doctor came back to nurses' station briefly why patient was being moved

11:46 AM: Patient was done being moved, Doctor reentered room, screen changed to reflect new room number

11:56 AM: Doctor done with patient, doctor and nurse began discussing patient

11:58AM: Doctor and nurse done discussing patient

12:20 PM: Nurse commented they were just waiting for Social work and the patient would be done for the day

12:26PM: Social Worker came to the nursing station looking for nurse (who wasn't there)

12:27PM: Social Worker entered patient's room

1:40PM: Social Worker finished with patient

1:42PM: Nurse came back to patient's room

1:45 PM: Nurse and patient left- patient checked out at front desk

VITALS: 10 minutes

NURSE ASSESSMENT: 23 minutes

DOCTOR: 16 minutes

SOCIAL WORK: 73 minutes

DIETICAN: Unknown

**Patient 4 Timeline**

Appointment Date: November 29, 2016

Appointment Time: 10 AM

Patient Arrival: 9:46 AM

9:52AM: Patient screen changed to “Exam-Rm”

10:22AM: Patient screen changed to “Exam-Rm: Vitals Rm”

10:25AM: Patient is done with Vitals and waiting for room

10:26AM: Patient assigned to exam room

10:46AM: Patient moved out of exam room so Post- Transplant Patient could use that room, screen switched to “Exam-Rm”

11:03AM: Social Worker came to nurse station saying there was someone else in the room where they thought the patient was. Nurse and Social Worker went to find patient- learned he had been moved

11:04AM: Social Worker entered patient room to see them

11:06AM: Screen updated to reflect change in room for patient

11:58AM: Doctor and nurse began discussing patient

12:04PM: Social Worker done meeting with patient

12:05PM: Nurse, Social Worker, and Doctor began discussing patient

12:08PM: Doctor went to see patient

12:19PM: Doctor done seeing patient- nurse and doctor began discussing

12:20PM: Doctor and nurse done discussing- doctor left for the day

12:23PM: Nurse took patient to get their labs (thinking that was the last thing they needed)

12:30PM: Realized patient might not have seen the dietitian

12:35PM: Dietitian came back and said they had not yet seen the patient

12:36PM: Patient done with labs

12:39 PM: Nurse went to check on patient

12:42PM: Nurse back from checking on patient

12:49 PM: Nurse and dietitian talked briefly

12:52PM: Dietitian went in to see patient

1:09PM: Dietitian done meeting with patient- patient left

VITALS: 3 minutes

SOCIAL WORK: 60 minutes

DOCTOR: 11 minutes

LABS: 13 minutes

DIETITIAN: 17 minutes

**Patient 5 Timeline- WAITLIST PATIENT- Check In**

Appointment Date: November 29, 2016

Appointment Time: 10:15 AM

Patient Arrival: 9:55AM

10:25AM: Patient waiting on room

10:33AM Patient assigned room

10:56AM: Nurse and doctor began discussing patient

11:03AM: Nurse and doctor done discussing- doctor entered patient's room

11:30 AM: Doctor done meeting with patient

11:30 AM: Dietitian entered patient's room

11:41 AM: Dietitian done meeting with patient- dietitian and nurse began discussing patient

11:43AM: Dietitian and nurse done discussing

12:14 PM: patient flagged down dietitian to see if they could leave (hadn't seen anyone since dietitian); dietitian returned to nursing station looking for nurse who wasn't there, tried to call nurse but there was no answer, dietitian went around floor looking for nurse

12:17PM: Nurse returned and reported patient just left

WAITING BEFORE A ROOM: 30 minutes

NURSE: about 23 minutes

DOCTOR: 27 minutes

DIETITIAN: 9 minutes

**Patient 6 Timeline**

Appointment Date: December 5, 2016

Appointment Time: 10:00 AM

Patient Arrival: 9:45 AM

10:06AM: Vitals Room

10:12AM: Screen switched to "exam-rm"

10:23AM: Supposedly assigned a room

10:24AM: Marianne went to go figure out what rooms all the patients were in (patients 6, 7, and 8)

10:25AM: Getting labs

10:31AM: Assigned a room (1158)

10:32AM: Nurse went to check patient in

10:50AM: Dot changed to blue- ready for social work

10:56AM: Began discussing patient with doctor- got distracted by chaos

10:57AM: Social Work went in

11:28AM: Social Work done (assessment completed ahead of time)

11:37AM: Doctor looking over charts for patient

11:38 AM: Doctor and Nurse discussing

11:42AM: Doctor went to see patient

11:56 AM: Doctor done with patient

11:56AM: Dietitian went in

12:24 PM: Dietitian done

12:29 PM: Patient left

VITALS: 6 minutes

LABS:7 minutes

NURSE: 18 minutes

SOCIAL WORK: 31 minutes

TRANSPLANT DOCTOR: 14 minutes

DIETITIAN:28 min

**Patient 7 Timeline**

Appointment Date: December 5, 2016

Appointment Time: 10:00 AM

Patient Arrival: 10:04 AM

10:06AM: Screen switched to “Exam-Rm”

10:26AM: Still in waiting room

10:38AM: Screen switched to “Vitals Rm”

10:46AM: Screen switched to “Exam-Rm”

10:58AM: Screen switched to “Exam-Rm: 1188”

11:16AM: Nurse went to see

11:27AM: Nurse done with patient; Nurse and doctor began discussing patient

11:32AM: Doctor went to see patient

11:38AM: Doctor done seeing patient

11:42AM: Social Work went to see patient

12:36PM: Social Work done seeing patient

12:45PM: Nurse went to check on (waiting for dietitian to finish with other patient to see)

12:47PM: Nurse came back from seeing patient

12:56PM: Dietitian went in

1:15PM: Dietitian done and patient left

WAITING BEFORE STARTING: 34 minutes

VITALS: 8 minutes

NURSE: 11 minutes

DOCTOR: 6 minutes

SOCIAL WORK: 54 minutes

DIETITIAN: 19 minutes

**Patient 8 Timeline**

Appointment Date: December 5, 2016

Appointment Time: 10:00 AM

Patient Arrival: 10:07 AM

10:25AM: Patient getting labs

10:33AM: Assigned a room

10:34AM: Screen changed to "vitals room"

10:38AM: Screen changed back to "Exam-Rm"

10:41AM: Screen changed to have the actual exam room number

11:02AM: Nurse went to see

11:14AM: Nurse done seeing; Nurse, doctor, and Social Work began discussing patient

11:16AM: Doctor went to see

11:21AM: Doctor done seeing

11:29 AM: Dietitian went in

11:48AM: Dietitian done

11:48AM: Nurse went to tell Social Work they were ready

12:08 PM: Social Work went in

12:42PM: Social Work done

12:45: Called down to finance to have them come up

1:00PM: Finance done and patient left

WAITING IN MAIN WAITING ROOM: 18 minutes

LABS: about 8 minutes

VITALS: about 4 minutes

NURSE: 12 minutes

DOCTOR: 5 minutes

DIETITIAN: 19 minutes

SOCIAL WORK: 34 minutes

FINANCE: about 15 minutes

## Appendix B: Aggregated Patient Observation Data

All values are times displayed in minutes; All data was collected on Tuesday mornings

| Date | Patient | Vitals | Labs | Nurse | Doctor | Dietitian | Social Work | Finance |
|---|---|---|---|---|---|---|---|---|
| **11/22/16** | **Patient 1** | | | 21 | 19 | 20 | 42 | |
| **11/22/16** | **Patient 2** | | | | 35 | 19 | 69 | |
| **11/29/16** | **Patient 3** | 10 | | 23 | 16 | | 73 | |
| **11/29/16** | **Patient 4** | 3 | 13 | | 11 | 17 | 60 | |
| **12/5/16** | **Patient 6** | 6 | 7 | 18 | 14 | 28 | 31 | |
| **12/5/16** | **Patient 7** | 8 | | 11 | 6 | 19 | 54 | |
| **12/5/16** | **Patient 8** | 4 | 8 | 12 | 5 | 19 | 34 | 15 |
| **AVERAGES (W/O WL PATIENT)** | | **6** | **9** | **17** | **15** | **20** | **52** | **15** |
| 11/29/16 | Patient 5 (**WAITLIST PATIENT) | | | 23 | 27 | 9 | | |
| **AVERAGES (INCLUDE WL)** | | **6** | **9** | **18** | **17** | **19** | **52** | **15** |